Project	**IEEE 802 Executive Committee Study Group on Mobile Broadband Wireless Access** <http://ieee802.org/20>	
Title	**Summary of delay profiles for MBWA**	
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Re:	802.20 WG Call for Contributions	
Abstract	This document provides summary of delay profiles that major international standard organizations suggested.	
Purpose	Contribute to the discussion and development of the 802.20 Requirements and Channel Model.	
Notice		

Summary of Delay Profiles for MBWA

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Contents

Rationale

- The intention of this contribution is to help discussions on delay spread in IEEE 802.20 MBWA.
- Delay profile is very important since it can have major impact on the system performance.
- Agreement needed on specific model set for evaluation criteria

Delay Profiles by ITU[1]-i

- Parameters for channel impulse response model
  - Channel A: low delay spread case
  - Channel B: median delay spread case

Test environment	Channel A		Channel B	
	r.m.s. (ns)	*P* (%)	r.m.s. (ns)	*P* (%)
Indoor office	35	50	100	45
Outdoor to indoor and pedestrian	45	40	750	55
Vehicular – high antenna	370	40	4 000	55

Delay Profiles by ITU[1]-ii

- Indoor office environment

Tap	Channel A		Channel B		Doppler spectrum
	Relative delay (ns)	Average power (dB)	Relative delay (ns)	Average power (dB)	
1	0	0	0	0	Flat
2	50	–3.0	100	–3.6	Flat
3	110	–10.0	200	–7.2	Flat
4	170	–18.0	300	–10.8	Flat
5	290	–26.0	500	–18.0	Flat
6	310	–32.0	700	–25.2	Flat

Delay Profiles by ITU[1]-iii

- Outdoor to indoor and pedestrian environment

Tap	Channel A		Channel B		Doppler spectrum
	Relative delay (ns)	Average power (dB)	Relative delay (ns)	Average power (dB)	
1	0	0	0	0	Classic
2	110	–9.7	200	–0.9	Classic
3	190	–19.2	800	–4.9	Classic
4	410	–22.8	1 200	–8.0	Classic
5	–	–	2 300	–7.8	Classic
6	–	–	3 700	–23.9	Classic

Delay Profiles by ITU[1]-iv

- Vehicular environment

Tap	Channel A		Channel B		Doppler spectrum
	Relative delay (ns)	Average power (dB)	Relative delay (ns)	Average power (dB)	
1	0	0.0	0	−2.5	Classic
2	310	−1.0	300	0	Classic
3	710	−9.0	*8.900*	−12.8	Classic
4	1 090	−10.0	*12 900*	−10.0	Classic
5	1 730	−15.0	*17 100*	−25.2	Classic
6	2 510	−20.0	*20 000*	−16.0	Classic

Delay profiles by COST 259[2]-i (TU, Typical Urban)

Tap number	Relative time (μs)	average relative power (dB)	doppler spectrum
1	0	-5.7	Class
2	0.217	-7.6	Class
3	0.512	-10.1	Class
4	0.514	-10.2	Class
5	0.517	-10.2	Class
6	0.674	-11.5	Class
7	0.882	-13.4	Class
8	1.230	-16.3	Class
9	1.287	-16.9	Class
10	1.311	-17.1	Class
11	1.349	-17.4	Class
12	1.533	-19.0	Class
13	1.535	-19.0	Class
14	1.622	-19.8	Class
15	1.818	-21.5	Class
16	1.836	-21.6	Class
17	1.884	-22.1	Class
18	1.943	-22.6	Class
19	2.048	-23.5	Class
20	2.140	-24.3	Class

Delay profiles by COST 259[2]-ii (RA, Rural Area)

Tap number	Relative time (μs)	average relative power (dB)	doppler spectrum
1	0	-5.2	Direct path, $f_s = 0.7 \cdot f_D$
2	0.042	-6.4	Class
3	0.101	-8.4	Class
4	0.129	-9.3	Class
5	0.149	-10.0	Class
6	0.245	-13.1	Class
7	0.312	-15.3	Class
8	0.410	-18.5	Class
9	0.469	-20.4	Class
10	0.528	-22.4	Class

Delay profiles by COST 259[2]-iii (HT, Hilly Terrain)

Tap number	Relative time (μs)	average relative power (dB)	doppler spectrum
1	0	-3.6	Class
2	0.356	-8.9	Class
3	0.441	-10.2	Class
4	0.528	-11.5	Class
5	0.546	-11.8	Class
6	0.609	-12.7	Class
7	0.625	-13.0	Class
8	0.842	-16.2	Class
9	0.916	-17.3	Class
10	0.941	-17.7	Class
11	*15.000*	-17.6	Class
12	*16.172*	-22.7	Class
13	*16.492*	-24.1	Class
14	*16.876*	-25.8	Class
15	*16.882*	-25.8	Class
16	*16.978*	-26.2	Class
17	*17.615*	-29.0	Class
18	*17.827*	-29.9	Class
19	*17.849*	-30.0	Class
20	*18.016*	-30.7	Class

Delay profiles by 3GPP[3]-i

Case 1, speed 3km/h		Case 2, speed 3 km/h		Case 3, speed 120 km/h		Case 4, speed 3 km/h		* Case 5, speed 50 km/h		Case 6, speed 250 km/h	
Relative Delay [ns]	Relative mean Power [dB]	Relative Delay [ns]	Relative mean Power [dB]	Relative Delay [ns]	Relative mean Power [dB]	Relative Delay [ns]	Relative mean Power [dB]	Relative Delay [ns]	Relative mean Power [dB]	Relative Delay [ns]	Relative mean Power [dB]
0	0	0	0	0	0	0	0	0	0	0	0
976	-10	976	0	260	-3	976	0	976	-10	260	-3
		20000	0	521	-6					521	-6
				781	-9					781	-9

- All taps have classical Doppler spectrum.

Delay profiles by 3GPP[3]-ii

Case 7, speed 50 km/h		
Relative Delay [ns]	Average Power [dB]	
	Sector	Beam
0	0.0	-
260	-4.3	-
1040	-6.6	-
4690	-2.0	0.0
7290	-7.0	-0.3
14580	-7.5	-0.9

- All taps have classical Doppler spectrum.

Delay profiles by 3GPP2[4]-i

Channel Model	Multi-path Model	# of Fingers	Speed (kmph)	Fading	Assignment Probability
Model A	Pedestrian A	1	3	Jakes	0.30
Model B	Pedestrian B	3	10	Jakes	0.30
Model C	Vehicular A	2	30	Jakes	0.20
Model D	Pedestrian A	1	120	Jakes	0.10
Model E	Single path	1	0, f_D=1.5 Hz	Rician Factor K = 10 dB	0.10

Delay profiles by 3GPP2[4]-ii

Model	Finger 1 (dB)	Delay	Finger2 (dB)	Delay (Tc)	Finger 3 (dB)	Delay (Tc)	FURP[1] (dB)
Ped-A	-0.06	0.0					-18.8606
Ped-B	-1.64	0.0	-7.8	1.23	-11.7	2.83	-10.9151
Veh-A	-0.9	0.0	-10.3	1.23			-10.2759

- FURP: Fractional UnRecovered Power shall contribute to the interference of the finger demodulator outputs as an independent fader.

Another delay profile reported

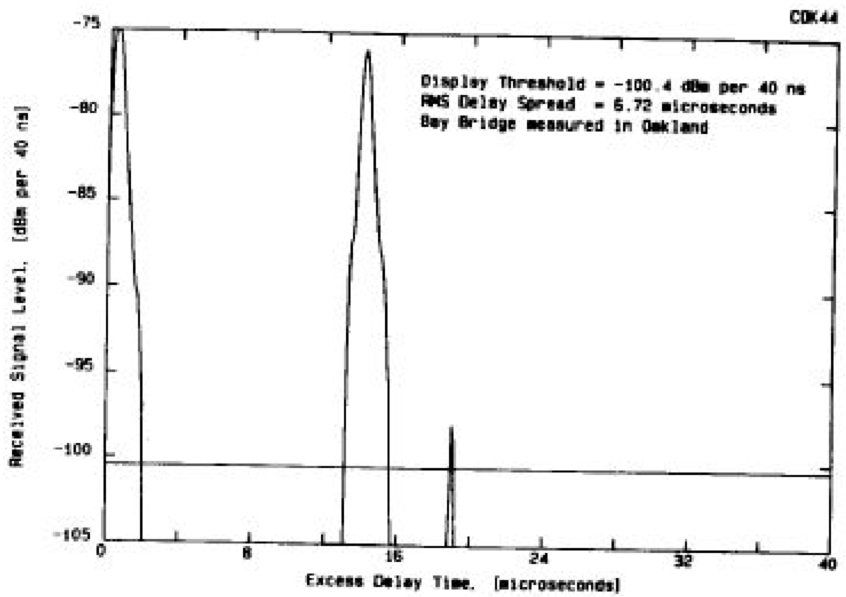

Figure 3. Measurement in Oakland, CA. Mobile transmitter on Bay Bridge, San Francisco Side. Rms delay spread of 6.7 us is typical for elevated areas in urban areas (absolute power, log scale).

- Rappaport, T.S.; Seidel, S.Y.; Singh, R., "900 MHz multipath propagation measurements for US digital cellular radiotelephone," Global Telecommunications Conference, 1989, and Exhibition. 'Communications Technology for the 1990s and Beyond'. GLOBECOM '89., IEEE , 27-30 Nov. 1989, Page(s): 84 -89 vol.1
- Worst profile case for typical operating locations
- RMS delay spread
  - Urban: 2-3 us
  - Hilly: 5-7 us

Concluding Remarks

- Delay spread is less than 10 us for most cases.
- But there are certainly cases where the maximum delay spread is longer than 10 us in both ITU and European COST models:
  - ITU model vehicular channel B,
  - COST 259 HT,
  - 3GPP model Cases 2 and 7.

Recommendations

- Explicit requirement for delay spread?
- Performance evaluation
  - Having multi-delay profiles is reasonable for exact performance evaluation
  - One profile needs to include taps having delay larger than 10 microseconds. → What performance does MBWA have with large delay spreads?
- ITU-R M.1225
  - 'Although large delay spreads occur relatively infrequently, they can have a major impact on system performance.'
  - 'To accurately evaluate the relative performance of candidate RTTs, it is desirable to model the variability of delay spread as well as the "worst case" locations where delay spread is relatively large.'

References

1. RECOMMENDATION ITU-R M.1225, “GUIDELINES FOR EVALUATION OF RADIO TRANSMISSION TECHNOLOGIES FOR IMT-2000,” 1997.
2. 3GPP TR 25.943, “Deployment aspects,“ June 2002.
3. 3GPP TS 25.101, "UE Radio Transmission and Reception (FDD),“ December 2002.
4. 3GPP2 TSG-C.R1002, “1xEV-DV Evaluation Methodology (V13.1)”.